[241] Attorney Docket No. : CPL-126US PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Tasso R. M. Sales
Serial No.	:	10/072,014
Filed	:	February 7, 2002
For	:	HIGH-CONTRAST SCREEN WITH RANDOM MICROLENS ARRAY
Examiner	:	C. Mahoney
Group	:	2851

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CERTIFICATION OF FACSIMILE TRANSMISSION

I hereby certify that the following papers are being facsimile transmitted to the United States Patent and Trademark Office on the 18th day of July, 2003:

1. Supplemental Information Disclosure Statement (2 pages)
2. Supplemental Modified 1449 Form (1 page)
3. Cited Reference(10 pages)

Total number of pages faxed including this page: 14

7/18/03
Date

Maurice Klee
Maurice M. Klee, Ph.D.

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SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

In accordance with 37 CFR §1.56, 37 CFR §1.97(c) and 37 CFR §1.97(e)(2), applicant wishes to call the Examiner's attention to Reference 53 listed on the Supplemental Modified 1449 Form submitted herewith. A copy of the reference is submitted herewith.

Reference 53 is an English translation of Japanese Patent Publication No. 11-101902 (the '902 publication), which was previously made of record in applicant's September 19, 2002 Supplemental Information Disclosure Statement. As indicated therein, the '902 publication was cited in a July 9, 2002 International Search Report regarding International Application No. PCT/US02/03665, which, like this application, claims priority from U.S. Provisional Application No. 60/267,037.

The undersigned arranged to have an English translation prepared for the '902 publication and that translation was received on July 10, 2003. Reference 53 (the translation) was thus not known to any individual designated in 37 CFR §1.56(c) more than three months prior to the filing of this statement. Nor was the translation cited in any communication from a foreign patent office in a counterpart foreign application. Accordingly, no fee under 37 CFR §1.17(p) is believed to be due for this submission. However, if a fee is required, applicant requests that the fee be charged to Deposit Account No. 11-1158.

The Examiner is respectfully requested to initial a copy of the Supplemental Modified 1449 Form and return it to applicant to indicate consideration of the reference listed thereon in connection with the prosecution of this application.

Respectfully submitted,

Date: 7/18/03 Maurice Klee

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SUPPLEMENTAL MODIFIED 1449 FORM

OTHER ART

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Examiner Initial

________ 53. Translation of Japanese Patent Publication No. 11-101902.

JAPANESE PATENT OFFICE
PATENT JOURNAL (A)
KOKAI PATENT APPLICATION NO. HEI 11[1999]-101902

Int. Cl.^{6}:	G 02 B 5/02 3/00 G 02 F 1/1335
Filing No.:	Hei 9[1997]-279853
Filing Date:	September 25, 1997
Publication Date:	April 13, 1999
No. of Claims:	5 (Total of 5 pages; FD)
Examination Request:	Not filed

METHOD FOR MANUFACTURING A MICROLENS SHEET WITH LIGHT-SHIELDING MATRIX

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[There are no amendments to this patent.]

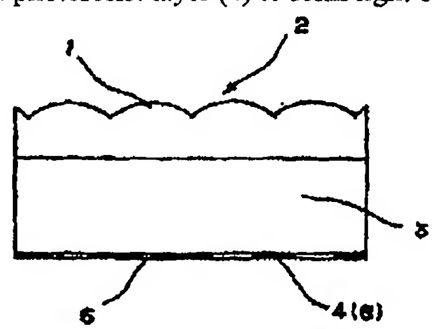
Abstract

Object

The object of the present invention is to provide a method for manufacturing a microlens sheet with a light-shielding matrix without requiring alignment and bonding.

Constitution

Light is irradiated onto microlens sheet (2), which has photoresist layer (4) that contains a light-shielding agent on the side opposite the microlens (1), from the lens side to expose said photoresist layer (4); after exposure, said photoresist layer (4) is developed, so that opening portions (5) are formed on said photoresist layer (4) to form light-shielding matrix (6).



Claims

1. A method for manufacturing a microlens sheet with a light-shielding matrix characterized by a microlens sheet with a photoresist layer that contains a light-shielding agent on the side opposite to the side of the microlens, on which light is irradiated from the lens side to expose said photoresist layer, wherein after exposure, said photoresist layer is developed, so that opening portions are formed on said photoresist layer to form a light-shielding matrix.

2. The manufacturing method of Claim 1 characterized by the fact that said photoresist layer is a positive photoresist layer.

3. The manufacturing method of Claim 1 or 2 characterized by the fact that said light-shielding agent is carbon black.

4. The manufacturing method of any of Claims 1-3 characterized by the fact that said microlens sheet is a microlens sheet with unit lenses arranged periodically in an array.

5. The manufacturing method of Claim 4 characterized by the fact that said lenses are hemispherical lenses.

Detailed explanation of the invention

[0001]

Technical field of the invention

The present invention pertains to a method for manufacturing a microlens sheet with light-shielding matrix for use in liquid-crystal displays, etc. More specifically, the present invention pertains to a method for manufacturing a microlens sheet with a light-shielding matrix characterized by the fact that it is free of the time-consuming process of aligning the focal points of each unit lens of the microlens sheet with the corresponding opening portion of the matrix, so that the microlens sheet with a light-shielding matrix can be manufactured easily.

[0002]

Prior art

Since the display quality of a liquid-crystal display is a function of the viewing direction, that is, since it has a viewing angle dependence, the field of view is small, which is undesirable. In order to solve this problem, a microlens sheet is arranged on the viewing plane of the liquid-crystal display. The microlens sheet is typically a sheet with unit lenses arranged periodically in an array. However, it is difficult to obtain a high-quality image using only the microlens sheet due to the presence of indoor lighting, sunlight, and light from the periphery of the display device. In order to prevent reflection of the peripheral light in order to obtain an image of higher quality, the microlens sheet is combined with a matrix containing carbon black as a light-shielding agent (hereinafter referred to as black matrix).

[0003]

Usually, in order to combine the microlens sheet with the black matrix, the microlens sheet and the black matrix are bonded together. In order to do this, however, it is necessary to correctly align the focal points of each lens unit of the microlens sheet with the corresponding openings of the black matrix (with high precision). Consequently, during the design stage of the prism sheet and black matrix, precise calculations must be performed. Also, it is necessary to bond the black matrix and the microlens sheet such that the focal points of each lens unit is aligned with the corresponding openings of the black matrix.

[0004]

For example, Japanese Kokai Patent Application No. Hei 9[1997]-197106 describes a bonding technology for forming a microlens sheet with a black matrix. In this method, first of all, a UV curable resin containing carbon black is coated on polyethylene terephthalate. Using a photomask with a stripe-like pattern, UV light is irradiated to cure the resin. The uncured portions are dissolved using a developing solution to form a substrate having a light-shielding layer in the form of a matrix. Then, the center line in the light-shielding layer is aligned with the edge line of the mold of the microlens sheet filled with UV-curable resin. Then, UV light is irradiated to form a microlens sheet with a black matrix. However, as described above, it is a rather time-consuming process to adjust the alignment between the central line of the light-shielding layer and the edge line of the mold.

[0005]

Moreover, in recent years, the size of the microlens sheet and black matrix has had to increase as liquid-crystal displays have become larger. But since the microlens sheet and black matrix are designed on the basis of precise calculations, alignment and bonding are made even more difficult. As a result, the image quality of the liquid-crystal display will be poor. There is therefore a demand to develop a simple manufacturing method for a microlens sheet that has excellent light-shielding property that can improve the image quality.

[0006]

Problems to be solved by the invention

The purpose of the present invention is to solve the aforementioned problems of the prior art by providing a method for easily manufacturing a microlens sheet with light-shielding matrix characterized by the fact that no alignment and bonding are required.

[0007]

Means for solving the problem

The present invention offers a method for manufacturing a microlens sheet with light-shielding matrix characterized in that the microlens sheet has a photoresist layer that contains a light-shielding agent on the side opposite the side of the microlenses, wherein light is irradiated from the lens side to expose said photoresist layer and after exposure, said photoresist layer is developed, so that openings are formed in said photoresist layer to form a light-shielding matrix.

[0008]

In a preferred embodiment, the aforementioned photoresist layer is a positive photoresist layer that contains carbon black.

[0009]

In another preferred embodiment, the aforementioned microlens sheet is made up of unit lenses arranged periodically in an array.

[0010]

In still another preferred embodiment, the aforementioned lenses are hemispherical lenses.

[0011]

Embodiments of the invention

There is no particular limitation as to the shape of the microlens sheet for use in the present invention. However, it is preferred that the microlens sheet have unit lenses arranged periodically in an array. The shape, pitch, etc., of the unit lenses of the microlens sheet can be appropriately selected with respect to the form and size of the liquid-crystal display, as desired, as well as the pixel size, and the microlens material. The shape of the unit lenses may be hemispherical, prism-shaped, convex, etc. Also, it is not mandatory that the pitch of the unit lenses match the pixel pitch. It is preferred that the pitch of the unit lenses be 1/2 to 1/10 the pitch of the pixels as the manufacturing tolerance.

[0012]

Figure 1 is a diagram illustrating an example of the shape of the unit lenses and the shape of the microlens sheet. In the example shown in Figure 1, hemispherical lenses with a diameter twice the square root (√) of the unit lens pitch are set in a checkerboard pattern, with overlapping portions in the X-direction and Y-direction removed.

[0013]

There is no particular limitation on the type of material for the microlens sheet. Any transparent polymer material having a high light transmittance can be used. Examples include polycarbonate resin, polyester resin (polyethylene terephthalate, etc.), polysulfone resin, polyacrylate resin, acrylic resin, and other flexible resins (including sheets and films). Polycarbonate resin and UV curable acrylic resin are particularly preferred.

[0014]

The microlens sheet is a transparent layer with the desired thickness. The microlens sheet that has a transparent layer of the prescribed thickness may be prepared by forming it integrally, or it may be laminated, comprising a thin microlens layer and a transparent layer formed on the side opposite to the lens side. If the laminated structure is used, the material of the transparent layer may be the same or different from the material of the microlens layer. Also, "microlens sheet" is meant to include said laminated structure.

[0015]

The transparent layer of the microlens sheet is used to set the focal distance of the microlenses (unit lenses). That is, the focal distance of the microlenses is calculated, and a transparent layer with the prescribed thickness is arranged so that the photoresist layer, that is, the light-shielding matrix, is set at the position of the focal distance of the lenses. This is a constitutional requirement.

[0016]

Then, a photoresist layer containing a light-shielding agent is formed on the side opposite the lens side of the microlens sheet. The photoresist layer is formed on the side of the transparent layer when the transparent layer is integrated with the microlens sheet. Also, when the microlens sheet and the transparent layer have a laminated structure, first, the side opposite to the lens side and the transparent resin (transparent film or sheet) are bonded together to form a laminated structure. Then, a photoresist layer is formed on the transparent layer side of the laminated structure or a photoresist layer is formed first on one side of a transparent resin; then, the surface of the transparent resin on the side without the photoresist layer and the surface opposite to the lens side of the microlens layer are bonded together.

[0017]

It is preferred that the resin for forming the photoresist layer be a resin in which the light irradiated portions are soluble and can be removed by a development process. Examples of preferred resins that may be used include polymethyl methacrylate-based resins, naphthoquinonediamine-based resins, polybutyene-1-sulfone-based resins, etc. Of the preferred resins, m-cresol novolac resin, a quinone diazide-based resin, allows development in a dilute alkaline aqueous solution, and is thereby most preferred. However, the present invention is not limited to this type of resin.

[0018]

The resin for forming the photoresist layer (such as a positive type resin) contains a light-shielding agent. In the present invention, "light-shielding" means the ability to absorb light or prevent the reflection of light. Any material that can absorb light and/or prevent the reflection of light and does not affect resin dissolution and the development process may be used. Examples include metal oxides, pigments, dyes, etc. The preferred hue is a deep black. Carbon black, titanium black, and other pigments or black dyes are preferably used. Carbon black is the most appropriate. However, azo-based black dyes may also be used.

[0019]

Conventional methods may be adopted to form the photoresist layer containing the light-shielding agent. For example, the coating method may be used. For example, spin-coating may be used as the coating method. The thickness of the photoresist layer is preferably in the range of about 2-10 μm. If it is thinner than 2 μm, the anti-reflection performance of the light-shielding matrix produced will be compromised. On the other hand, if it is thicker than 10 μm, the exiting light rays may be blocked by the wall in the thickness direction of the light-shielding matrix, which also significantly impairs the quality of the image in a liquid-crystal display.

[0020]

The microlens sheet with photoresist layer that contains a light-shielding agent is then irradiated with light. Light is irradiated from the microlens side. The wavelength of the irradiated light is preferably in the range of 360-450 nm. The exposure is carried out with a collimated light beam from the microlens side that passes through the hemispherical lenses and is focused by each unit lens to perform exposure at the focal point. After exposure, the development process is carried out. The development process is a development method used with conventional resins; for example, a dilute alkaline aqueous solution, such as sodium metasilicate, sodium carbonate, etc, may be used. In this development process, openings are formed in the exposed portions. The size of each opening is preferably in the range of about 20-30% of the area of the unit lens. The exposure time is preferably selected in this range. When this range is not observed, color dispersion occurs, and the image quality of a liquid-crystal display will be significantly compromised.

[0021]

Application examples

An application example of the present invention pertaining to the formation of microlenses arranged in a periodic array having a black matrix will now be explained. However, the present invention is not limited to this application example.

Application example

A microlens sheet with a light-shielding matrix for liquid-crystal display having a display size of 921 x 518 mm was prepared. As shown in Figures 1 and 2, microlens sheet (2) with a microlens pitch of 70 μm, lens plane diameter of 99 μm, and height of 49.5 μm was formed from polycarbonate resin.

[0022]

For the transparent layer (3), a polycarbonate resin sheet with a thickness of 105 μm and was prepared without drawing. On one side, a 3-μm-thick layer of O-naphthoquinonediazide-based m-cresol-based novolac resin containing carbon black was formed with a spin coater to produce a polycarbonate resin sheet with a coated photoresist layer (4).

[0023]

The side of the polycarbonate resin sheet with the uncoated photoresist layer (4) and the side opposite to the lens side of said microlens sheet (2) are bonded together by means of polycarbonate resin dope. A collimated light beam whose wavelength is in the range of 365-380 nm was irradiated on the microlens side of the bonded and integrated sheet. The irradiation time was predetermined so that the size of each opening after development would be 25% of a square with a microlens pitch of 70 μm as each edge. Then, the exposed portion is developed in an aqueous solution of sodium metasilicate, thereby forming a microlens sheet with black matrix (6) with openings (5) formed therein.

[0024]

Obtained microlens sheet (2) was bonded on the viewing side of a liquid-crystal display with dimensions of 921 x 518 mm, with the surface of black matrix (6) in contact with the viewing side of the liquid-crystal display. As a result, the microlens sheet of the present invention has a significantly increased field of view, there is no reflection of light from the viewing side, and a high-quality image can be obtained.

[0025]

Comparative example

As in Application Example 1, a microlens sheet with a microlens pitch of 70 μm and with lens plane diameter of 99 μm and an undrawn polycarbonate resin sheet (thickness of 105 μm) were prepared. A black matrix was formed by screen-printing the polycarbonate resin sheet. The opening rate is 25% of the black matrix, like Application Example 1, by forming square openings with each edge 35 μm and set side-by-side in the X-axis and Y-axis directions with a pitch of 35 μm.

[0026]

The side opposite to the lens side of the microlens sheet and the side of the polycarbonate resin sheet on the side unprinted with black matrix were bonded together with polycarbonate dope, such that the center of each unit lens and the center of the corresponding opening in the black matrix are correctly aligned.

[0027]

The obtained microlens sheet with black matrix was evaluated in the same way as in Application Example 1. As a result, it was found that the field of view increased. However, color dispersion occurred, and the image quality was poor. Although the alignment was precise, the openings in the black matrix and the focal positions of the unit lenses in the microlens layer were not aligned.

[0028]

Effects of the invention

In the conventional manufacturing method of the microlens sheet with black matrix, a time-consuming process was required for correct alignment between the openings in the black matrix and the central portions of the microlens sheet. Also, only images of poor quality could be obtained. The present invention provides a manufacturing method for a high-quality microlens sheet with light-shielding matrix, which does not require precision alignment, yet produces high-quality images.

Brief description of the figures

Figure 1 is a top view illustrating an example of the microlens sheet of the present invention.

Figure 2 is a cross-sectional view across II-II in Figure 1.

Brief description of the part numbers

1 Microlens
2 Microlens sheet
3 Transparent layer
4 Photoresist layer
5 Openings
6 Black matrix

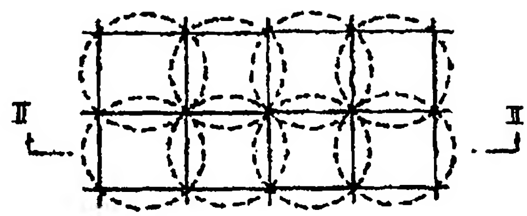


Figure 1

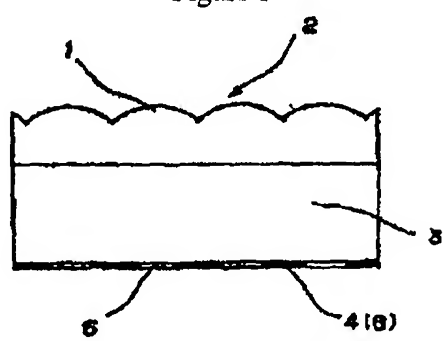


Figure 2